Non-pharmacological countermeasure to decrease landing sickness and improve functional performance

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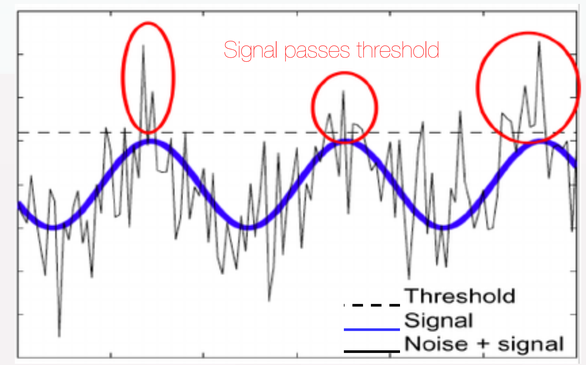
Background

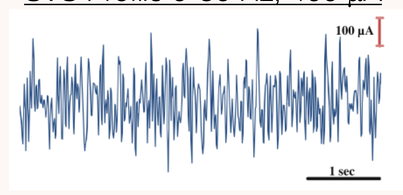
Upon return from long-duration spaceflight, 100% of crewmembers experience motion sickness (MS) symptoms. The interactions between crewmembers' adaptation to a gravitational transition, the performance decrements resulting from MS and/or use of promethazine (PMZ), and the constraints imposed by mission task demands could significantly challenge and limit an astronaut's ability to perform functional tasks during gravitational transitions.



Stochastic resonance (SR) is "noise benefit": adding noise to a system might increase the information (examples to the left and above). Stochastic vestibular stimulation (SVS), or low levels of noise applied to the vestibular system, improves balance and locomotor performance (Goel et al. 2015, Mulavara et al. 2011, 2015).

In hemi-lesioned rat models, Samoudi et al. 2012 found that SVS increased GABA release on the lesioned, but not the intact side. Activation of the GABA pathway is important in modulating MS and promoting adaptability (Cohen 2008) and was seen to reverse MS symptoms in rats after unilateral labyrinthectomy (Magnusson et al. 2000). Thus, SVS could be used to promote GABA pathways to reduce MS and promote adaptability, eliminate the need for PMZ or other performance-inhibiting drugs.

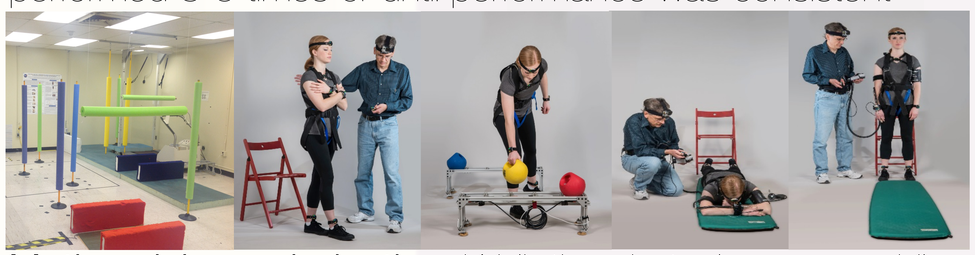
SVS Profile 0-30 Hz, 400 μA



Methods

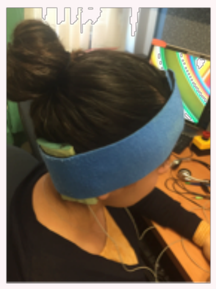
Healthy subjects (n=20) performed two identical counterbalanced sessions, one in which they received 400 μm SVS and one with 0 μm SVS. The protocol was as follows:

1. **Familiarization/baseline of 4 functional tasks:** Each task was performed 3-5 times or until performance was consistent



2. **Motion sickness induction:** Walk the obstacle course while wearing up/down reversing prisms (forward twice, reverse twice, forward once, reverse once) then read poster while making large up/down head movements at 1.33 Hz. Every 2 minutes subjects reported MS symptoms, this lasted 30 minutes or until MS=8.
3. **Post-motion sickness task performance:** Perform each task again after motion sickness induction.

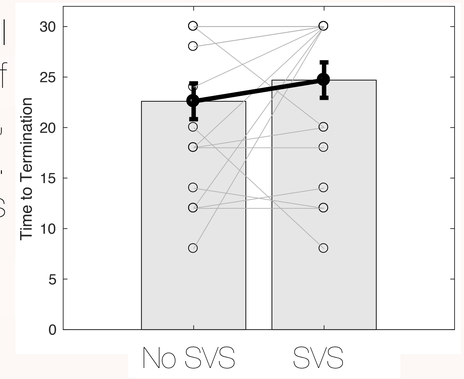
Left: Up/down reversing prism goggles used for motion sickness induction, pressure insoles, and body kinematic sensors used to record body movement.

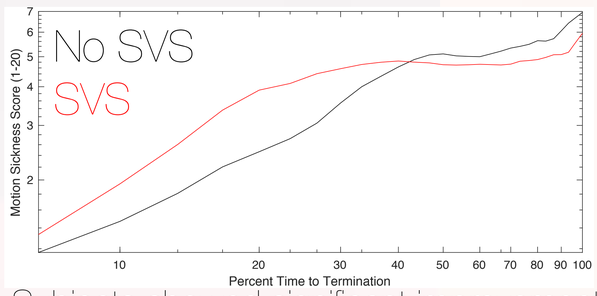


Up: SVS was delivered with electrodes placed behind the mastoid bone. Electrode gel, electrodes, and positioning are shown above.

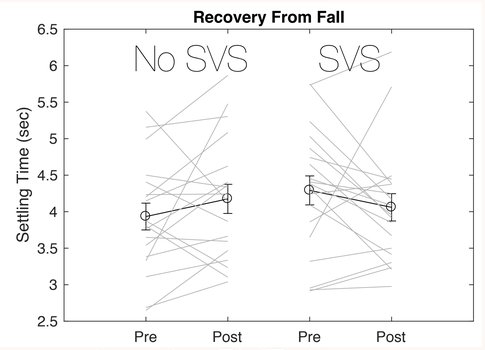
Results

Without SVS, only 40% of subjects lasted the full 30-minute MS induction protocol, while 65% of subjects lasted the full 30 minutes with SVS, which is nearly a significant increase (p=0.056). On average, subjects lasted 22.6 minutes without SVS and lasted 24.7 minutes with SVS.





MS symptoms appear to progress earlier, then plateau with SVS, while they steadily increase in severity without SVS.



Subjects showed significant improvement from baseline when performing the prone-to-stand test. The results are promising and future work includes comparing MS progression between PMZ and SVS directly in subjects that are provoked to a minimum of nausea. Low levels of SVS stimulation may serve as a non-pharmacological countermeasure to replace or reduce the PMZ dosage requirements and concurrently improve functional performance during transitions to new gravitational environments after spaceflight.

References

(1) Cohen B, Dai M, Yakushin SB, Raphan T, (2008) Baclofen, motion sickness susceptibility and the neural basis for velocity storage. Prog Brain Res 171, 543. **(2)** Goel, R., Kofman, I., Jeevarajan, J., De Dios, Y., Cohen, H. S., Bloomberg, J. J., & Mulavara, A. P. (2015). Using Low Levels of Stochastic Vestibular Stimulation to Improve Balance Function. PloS one, 10(8), e0136335. **(3)** Magnusson K, Lindstrom S, Tham R, (Sep, 2000) GABA(B) receptors contribute to vestibular compensation after unilateral labyrinthectomy in pigmented rats. Experimental brain research. Experimentelle Himforschung. Experimentation cerebrale 134, 32. **(4)** Mulavara AP, Fiedler MJ, Kofman IS, Wood SJ, Serrador JM, Peters B, Cohen HS, Reschke MF, Bloomberg JJ (2011) Improving balance function using vestibular stochastic resonance: Optimizing stimulus characteristics. Exp Brain Res. 210(2): 303-312. **(5)** Mulavara, A. P., Kofman, I. S., De Dios, Y. E., Miller, C., Peters, B. T., Goel, R., ... & Bloomberg, J. J. (2015). Using low levels of stochastic vestibular stimulation to improve locomotor stability. Frontiers in systems neuroscience,9. **(6)** Samoudi G, Nissbrandt H, Dutia MB, Bergquist F (2012) Noisy Galvanic Vestibular Stimulation Promotes GABA Release in the Substantia Nigra and Improves Locomotion in Hemiparkinsonian Rats. PLoS ONE 7(1): e29308. doi:10.1371/journal.pone.0029308

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